

Vision Ergonomics and Computer Vision Syndrome: Causes and Treatments

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What is Vision Ergonomics?

- By helping people to use their vision comfortably, we allow them to use their body safely.
- Key Concept:
 - Visual demands influence posture
 - “The Body Follows the Eyes”

Optometry's Role in Vision Ergonomics

- Optics
 - Provide proper optical corrections for refractive errors
- Treatment of Ocular Conditions
 - Therapeutic treatment of specific ocular conditions and disease
- Vision Therapy
 - Physical therapy for binocular vision problems

What is Computer Vision Syndrome (CVS)?

- The complex of ocular and musculoskeletal disorders associated with computer use.
- Recognized by the Occupational Safety and Health Administration (OSHA) as a problem associated with prolonged computer use.
- Recognized by the American Optometric Association as a repetitive stress injury.

How Common is CVS?

- Complaints of CVS are more common than those of carpal tunnel syndrome.
- Almost 20% of people will have carpal tunnel syndrome.
- 70% of computer users will have CVS symptoms.

How Common is CVS?

- Approximately 15% of patients who visit optometrists have a chief complaint involving CVS symptoms.
- Range of reported eye symptoms among computer users varies from 25 – 93% depending on the study.

Why is CVS so Common?

- Computer use Statistics per Eyecare Business, March 2003
 - 2 million new users start using the internet each month in the U.S. alone
 - 174 million people in the U.S. use computers
 - 45% of Americans use e-mail

Why is CVS so Common?

- Computer use Statistics per Eyecare Business, March 2003
 - 90% of children between 5 and 17 years old use computers
 - 30% of adults 55 and over use them
 - Computer use growing in low income households by 25% annually

CVS Symptoms

- Visual
- Ocular
- Postural
- Musculoskeletal

Visual CVS Symptoms

- Double vision
- Focusing problems
- Headaches
- Blurred vision
- Light sensitivity
- Glare discomfort
- After-images

Ocular CVS Symptoms

- Eyestrain
- Fatigue
- Soreness
- Irritation
- Dryness
- Burning
- Itching
- Redness
- Tearing

Musculoskeletal CVS symptoms

- Pain in the:
- Neck
- Shoulders
- Back
- Arms
- Wrists
- Hands
- Fingers

Postural CVS symptoms

- Tilting head back and leaning forward to see through bifocals or progressive lenses.
- Pulling far away from the monitor to see through the distance portion of glasses.
- Poor optical correction leads to ergonomically poor body posture because the body follows the eyes.

The Costs of Uncorrected CVS

- Ocular ache
- Physical pain
- Decreased morale
- Decreased quality of life
- Decreased productivity
- More lost work days
- More workers compensation claims

The Causes of CVS Symptoms are Numerous

- Uncorrected refractive error
- Improper working distances
- Lack of proper ergonomic workstation set-up
- Improper body positioning
- Poor lighting
- Glare
- Screen flicker
- Screen resolution
- Image size
- Poor screen contrast
- Poor viewing angle

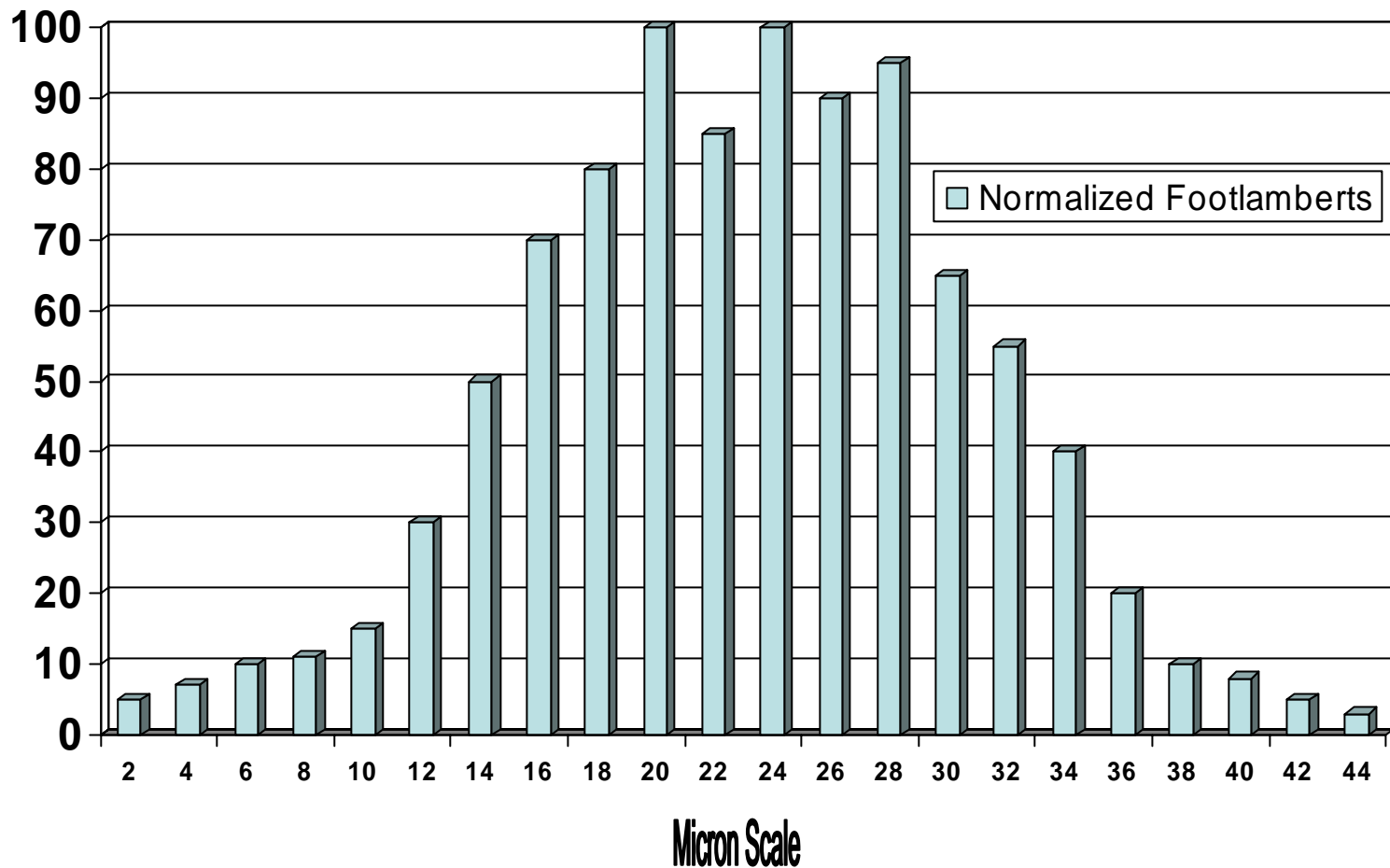
Causes of CVS Symptoms relating to Focusing (Accommodation).

- Contrast, spatial frequency and perceived blur all affect the ability of the eyes to focus properly, and the ease and speed with which we read text.
- Typical printed text provides high contrast between type characters and background, and provides sharp edge contours.

Causes of CVS Symptoms relating to Focusing (Accommodation).

- VDT screens, however, are made up of pixels (“picture elements”) that do not provide similarly high contrast characters with uniform density and sharp edge contours.
- Photometric measurements of the light from a single pixel show they are brightest centrally, and more dim and diffuse at the edges.

Light output from a single pixel (simulated plot)



Causes of CVS Symptoms relating to Focusing (Accommodation)

- These factors decrease focusing accuracy by causing our plane of focus to constantly be moving between the plane of the computer screen (about 67 cm), and the resting point of accommodation (about 200 cm).
- This is similar to how the automatic focus on a camera might keep continually shifting between different distances to find the proper focus.

Causes of CVS Symptoms relating to Focusing (Accommodation)

- Thus the eyes' automatic focus is engaged more continuously over a much greater range with computer viewing than with print viewing.
- This results in an overall greater fatigue on the visual system and increases eyestrain.

The Four Components of CVS Treatment

- Determine and provide proper optical correction at distance, intermediate and near.
- Assess ocular health and treat any underlying ocular conditions associated with CVS.
- Provide vision therapy for accommodative (focusing) or binocular vision dysfunction.
- Educate patients on workstation design.

Optical Corrections

- Providing proper optical correction for refractive error is **the starting point** and a **critical factor** in vision ergonomics.

Refractive Errors require Optical Corrections

- Myopia = “Near-sightedness”
 - Far objects blurry, near objects clear
- Hyperopia = “Far-sightedness”
 - Near objects blurry, far objects clear
- Astigmatism = Optical distortion
 - Corneal distortion induces some blur at all distances
- Presbyopia = “Old-sightedness”
 - Unable to focus near objects about age 45

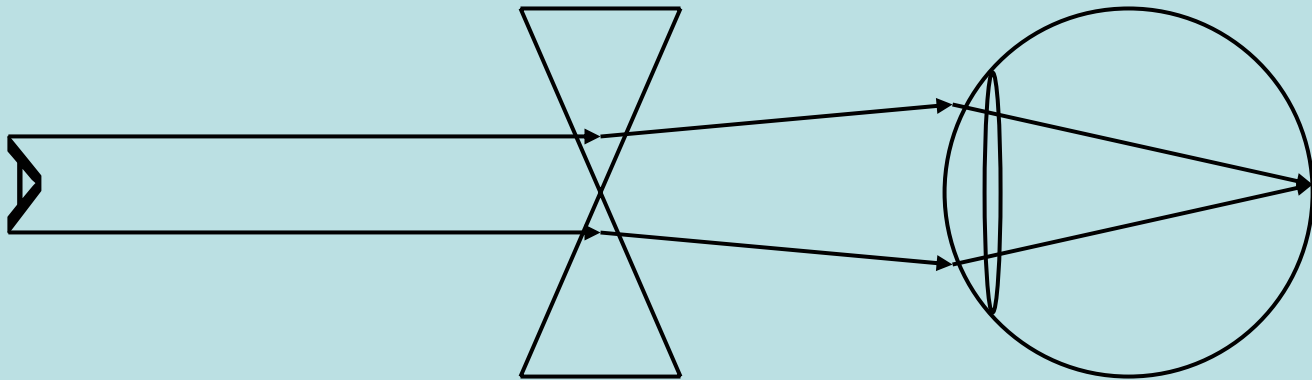
Myopia

- Myopic eye is “too powerful” or “too long”
- Image focused at point in front of retina
- Thus image is blurred at retina



Myopia Correction

- Minus (Concave) Lens diverges rays
- Image now focused on retina



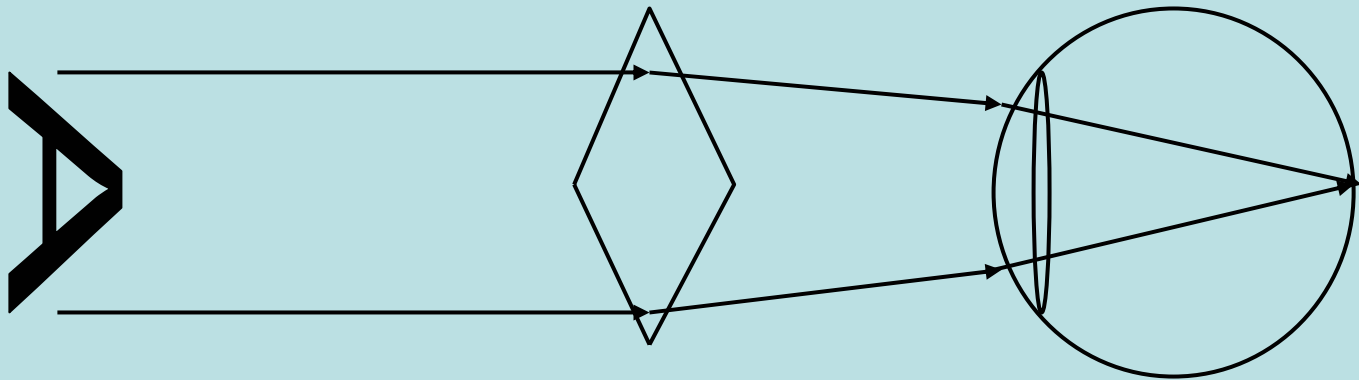
Hyperopia

- Hyperopic eye is “too weak” or “too short”
- Image focused at point behind retina
- Thus image is blurred at retina



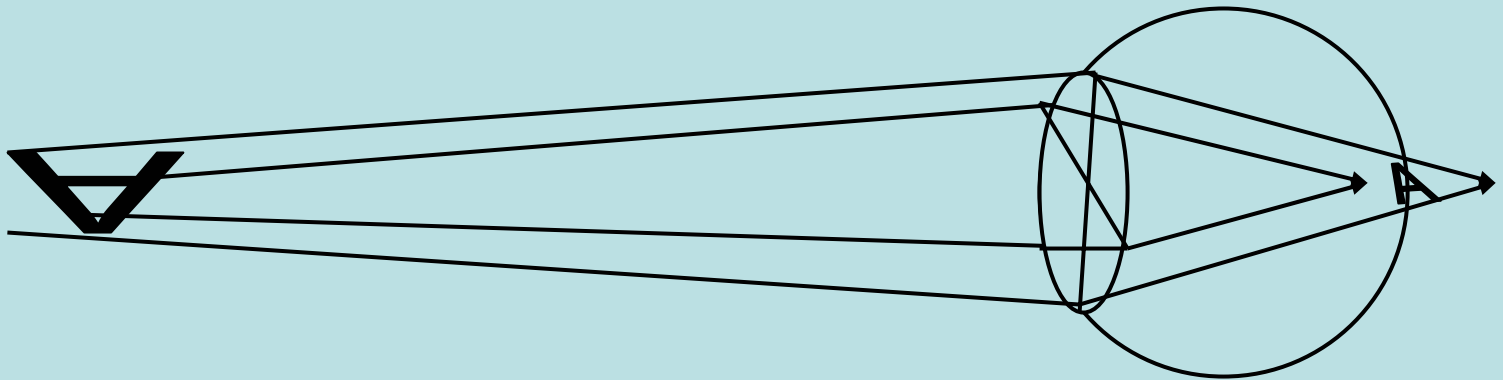
Hyperopia Correction

- Plus (Convex) Lens converges rays
- Image now focused on retina



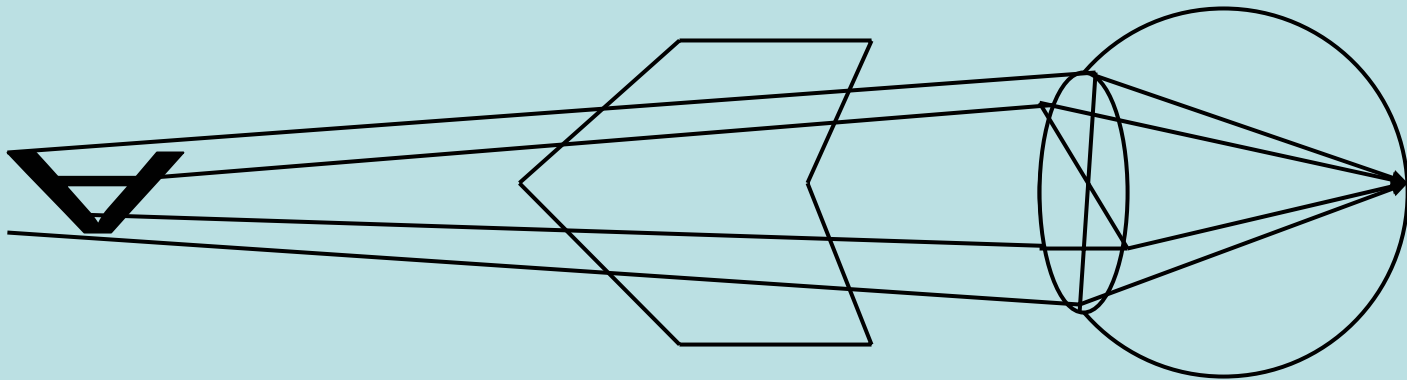
Astigmatism

- Corneal asymmetry distorts image
- Light rays focused at two different planes
- Thus image is blurred at retina



Astigmatism Correction

- Toric lens corrects image
- Image now focused onto retina



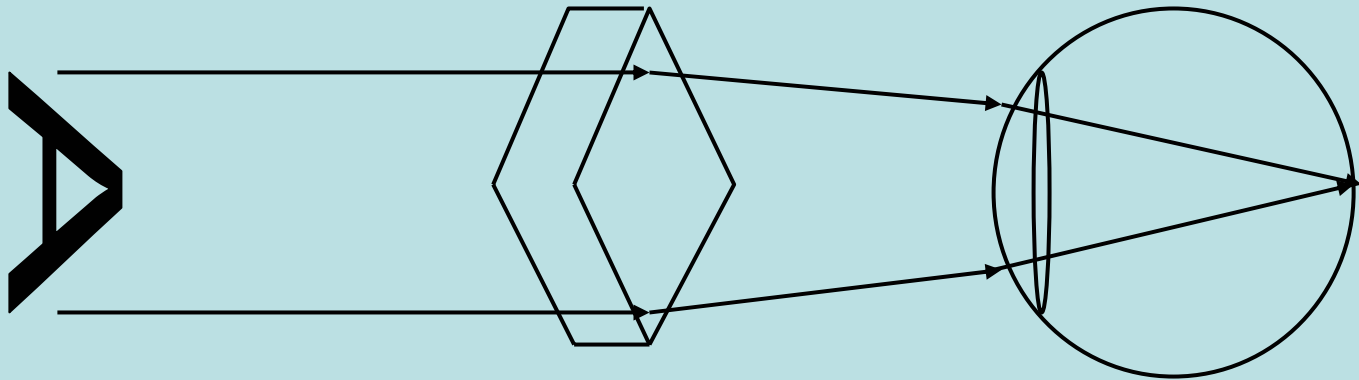
Presbyopia

- Presbyopic eye is now “too weak” at near
- Near objects focused behind retina
- Thus image is blurred at retina



Presbyopia Correction

- Plus Lens with Rx converges rays
- Image now focused on retina



Ergonomically Correct Workstation Set-up



Ergonomically Correct Workstation Posture

- Head supported by neck and spine.
- Back forms about a 90° angle with seat.
- Elbows bent at about 90° .
- Wrists have close to neutral angle to allow the least strain for keyboarding.
- Knees bent at about 90° with feet flat on the floor or at a slight angle on a footrest.

Ergonomically Incorrect Posture: Looking through Distance Rx



Ergonomically Incorrect Posture: Looking through Reading Rx



Determine the Working Distances

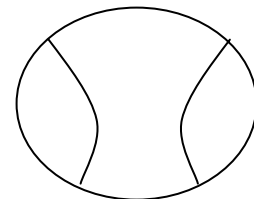
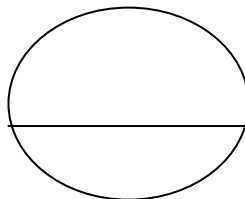
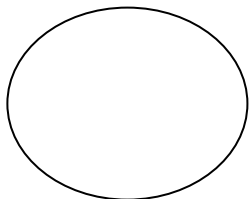
- Proper optical correction helps relieve the strain of CVS by allowing correct ergonomic posture and the relaxation of focusing.
- So, we need the appropriate distance Rx.
- And, we need to know the distance from the eyes to the working materials:
 - Eyes to monitor
 - Eyes to keyboard
 - Eyes to reference materials

Eye to Monitor Measurement in Ergonomically Correct Posture



Lens Styles

- Lenses may be single vision (SV), bifocal (BF), or computer progressive addition lenses (PAL).
- BFs come in several styles with different widths of the near portion of the lens.
- PALs are made by several different companies. These proprietary lenses have names like: AO Technica, Sola Access, Hoya Tact, Essilor Interview, Shamir Office, etc.



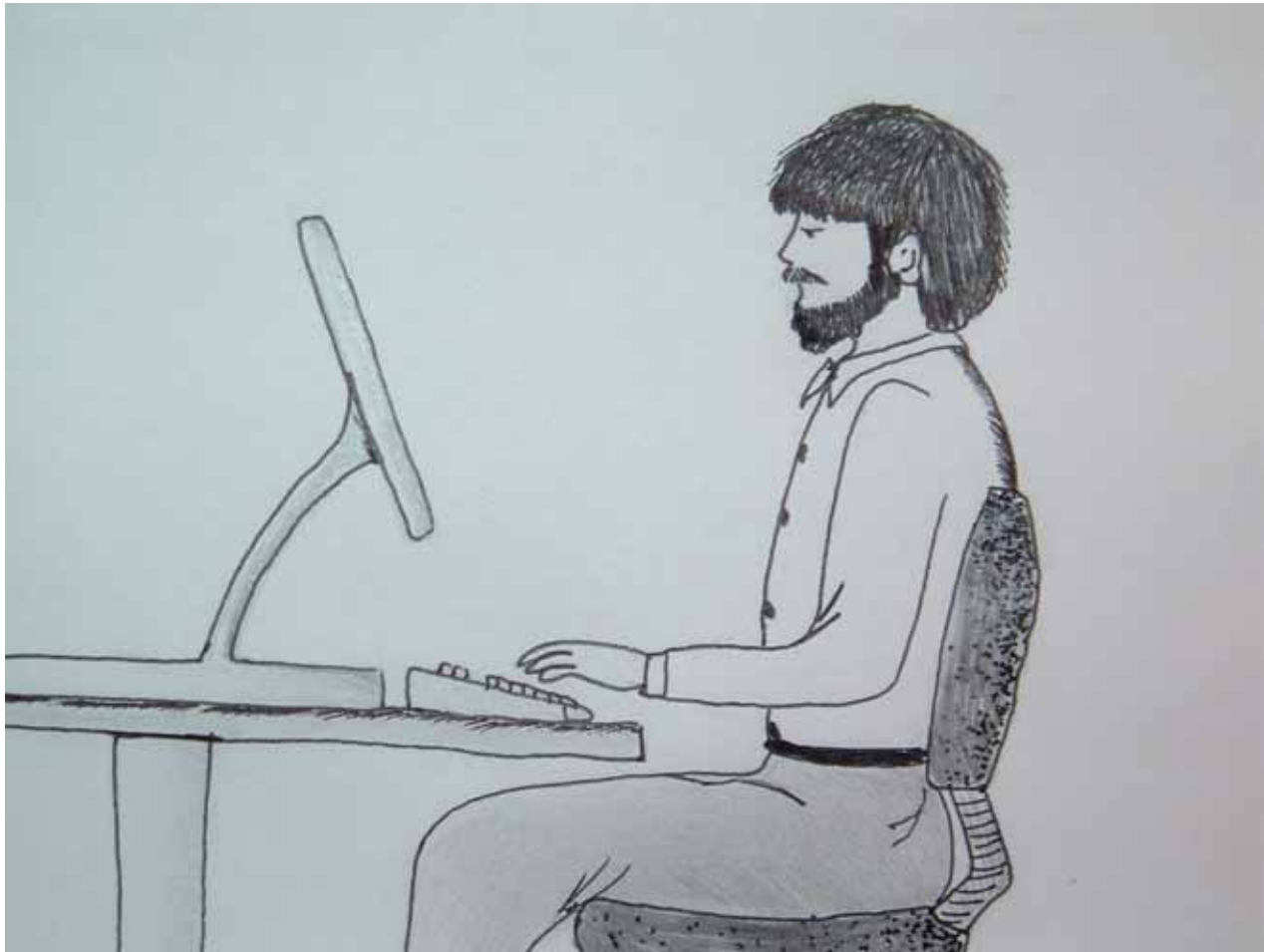
Lens Selection

- The choice of lens style is determined by the type of work that the patient does.
- Does he mostly only look at the VDT?
- Does she have to look at reference materials?
At what position and distances are they located?
- Does he look up to greet people who come to his desk?
- Does she greet people who are at the door of her office?
- The types of activities the person is engaged in will determine if they need SV, BF or PAL.

Addressing other causes of CVS

- Monitor Height
- Monitor Placement
- Monitor Type
- Viewing Angle
- Image Size
- Glare
- Screen resolution
- Screen flicker
- Screen contrast
- Document Placement
- Lighting

Ergonomically Correct Workstation Set-up



Monitor Angles and Distances

- The eyes-to-monitor distance generally ranges from about 20 to 26 inches.
- The center of the screen is about 10° - 20° below the line of sight.
- The monitor is tilted away from the viewer by 10° - 20° .

Monitor Height

- The center of the screen is placed 10°- 20° below the line of sight because a downward viewing angle:
 - Reduces chances of eyestrain, visual fatigue and headaches (Owens and Wolf-Kelly 1987; Tyrrell and Leibowitz 1990)
 - Allows less eye surface exposure which reduces risk of eye dryness (Sotoyama et al. 1995), a common ocular CVS symptoms
 - Less load exists from demands of convergence on the extraocular muscles when gaze is lowered (Heuer and Owens 1989)

Straight Ahead Viewing: Large Ocular Surface Exposure



Downward Viewing: Reduced Ocular Surface Exposure

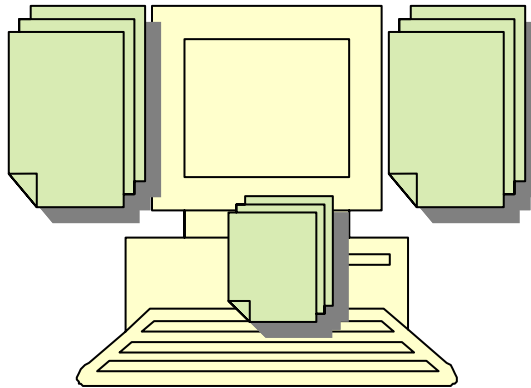


Monitor Tilt Angle

- Monitor Tilt at 10° - 20° allows for:
 - appropriate monitor height
 - provides a viewing plane perpendicular to the line of sight

Document Holder Placement

- Documents can be placed on either side, or in-line with monitor; in-line is best.



Monitors of the Past: CRT

- Heavy
- Large
- Stationary
- Use more energy
- Good resolution
- Screen Reflectance: High
- Flicker: Variable
- Inexpensive
- Viewing Angle: Great
- Good brightness and contrast controls

Monitors of the Present: LCD

- Light
- Small
- Mobile
- Use less energy
- Good resolution
- Screen
Reflectance: Low
- Flicker: none
- Costs decreasing
- Viewing Angle:
Good
- Good brightness
and contrast
controls

Visual Target Size

- For best visual comfort select font style based on how it scans (i.e. readability)
- Arial and Tahoma fonts are easiest to scan
- Font size selection is based on viewing distance
- Best visual comfort comes from choosing font that subtends about 20 minutes of arc at the retina
- At a 20 inch viewing distance, characters should be 3 to 4 mm in size (Grandjean 1987)

Screen color and contrast

- High contrast between characters and background is critical for visual comfort
 - low luminance v.s. high luminance
 - black on white
 - white on black (reversed polarity) – especially important to patients with eye diseases, such as Macular Degeneration or Cataracts
 - Any other highly contrasting colors

High Contrast

Normal Polarity

Reversed Polarity

Flicker, brightness and contrast

- Flicker perception best noted using peripheral vision
- Flicker threshold 45 to 50 Hz
- Monitor refresh rates adjustable from 60 to 80 Hz
- To decrease flicker perception:
 - Set refresh rate at highest rate available
 - Increase contrast setting and decrease brightness

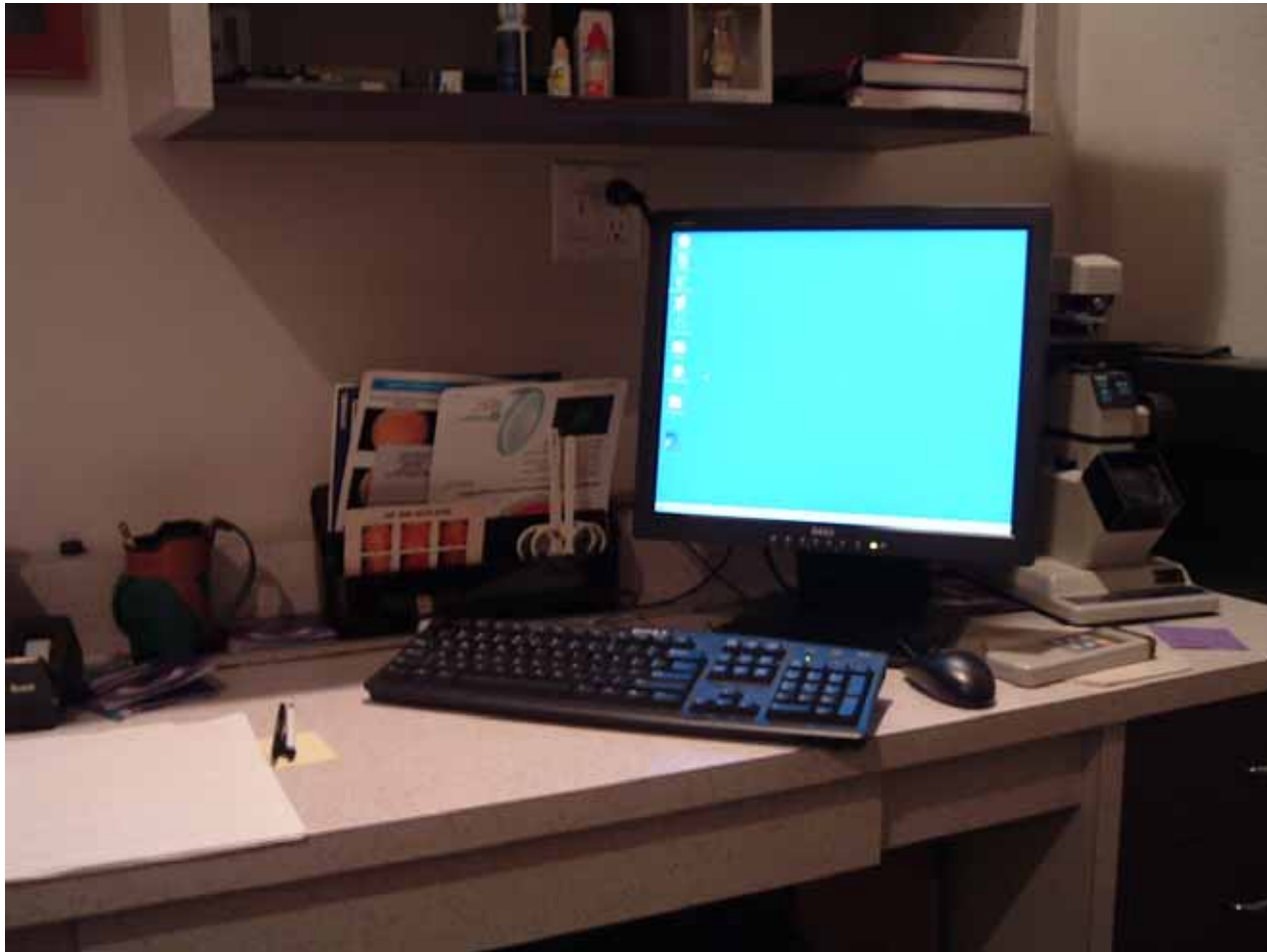
Lighting: Quantity

- Non-computer office work environments are generally around 1000 lux.
- The Lighting Handbook (Rea 2000), from the Illuminating Engineering Society of North America, recommends ambient illumination of 300 to 500 lux for intensive VDT use.
- Smaller task lights should then be used to illuminate reading materials.

Lighting: Luminance Ratios

- Recommended luminance ratios:
 - 3 : 1 luminance difference between the task (reading, computer screen) and immediate work area (desk).
 - 10 : 1 luminance difference between the task and outlying work areas (cubicle, office).

Luminance Ratios: 3 to 1, and 10 to 1



Glare: Types, Sources, Detection

- Three types of glare:
 - Direct from the light source
 - Indirect reflection off a glossy surface
 - Veiling reflection off a semiglossy surface
- The sources:
 - overhead, windows, task lights
- Detecting the sources:
 - hold hand as visor, shield screen with file folder, look at screen while it is off for reflections

Controlling Glare: Lighting

- Change lighting scheme:
 - Move lights and reflecting surfaces as far from line of sight as possible
 - Orient light sources so that indirect glare off of the screen, or veiling glare off of other objects is not produced
 - Use directional overhead lights with louvers, prismatic lenses or polarizing lenses
 - Lower the ambient lighting and use directional task lights, such as gooseneck lamps

Recessed Directional Light (note veiling glare off wall)



Controlling Glare: Workstation

- Change workstation area:
 - Move or tilt the monitor to avoid glare sources such as windows and lights
 - Place the screen perpendicular to windows
 - Use matte finishes at workstation and on walls
 - Cover windows with drapes, blinds or neutral density filters

Controlling Glare: Workstation

- Change workstation area:
 - Clean dust off computer and screen
 - Use an antiglare hood for screen
 - Use LCD monitors
 - Antiglare filters: polarizing filter, micromesh
 - AOA recommends circular polarized filters

Controlling Glare: Other Means

- Wear a visor
- Antireflective coating lens treatment
- Roll and polish lens edges for myopes
- Light grey or rose tint may increase comfort for people sensitive to short wavelengths (blue light) from fluorescent lights

The Four Components of CVS Treatment

- Determine and provide proper optical correction at distance, intermediate and near.
- Educate patients on workstation design.
- Provide vision therapy for accommodative (focusing) or binocular vision dysfunction.
- Assess ocular health and treat any underlying ocular conditions associated with CVS.

Anatomy: Ciliary and Extraocular Muscles

- Ciliary muscles:
 - Change shape of lens and affect Accommodation (focusing)
- 6 EOMs: Superior rectus, Inferior rectus, medial rectus, lateral rectus, inferior oblique, superior oblique
 - These muscles move the eyes in all directions and affect Binocular Vision

CVS, Accommodation and Binocular Vision Disorders

Accommodative

- Insufficiency
- Infacility
- Spasm

Binocular Vision

- Phorias
 - Eso, Exo, Vertical
- Convergence
 - Insufficiency
 - Excess

Vision Therapy for Binocular Vision and Accommodative Disorders

- Types: Pencil pushups, Accommodative Rock, Prism Rock, Stereograms, etc.
- Pro: ideal for accommodative problems and convergence insufficiency
- Con: requires strong commitment to the program from the patient (2 months or more, 5 days per week, with retainer training).

Optical Treatment of BV and Accommodative Disorders

- Lenses: Plus add power for reading and for working distance. Lens does the focusing for the patient.
- Prism: Prism power ground into lenses; moves images into alignment with eyes, and relieves strain on the visual system.

Optical Treatment of BV and Accommodative Disorders

- Pro: Lenses and prism provide optical compensation for the dysfunction and relieve eye strain quickly. Required for many binocular dysfunctions.
- Con: Mild disorders are not truly “fixed” as they might be with vision therapy. The patient will have to rely on the optical vision aids.

Ocular Disorders and Treatments

- Eyestrain
 - Causes:
 - Accommodative and Convergence fatigue
 - Treatments:
 - Appropriate refractive correction
 - Take breaks
 - Perform other types of tasks or office work
 - “20/20/20 rule”

Ocular Disorders and Treatments

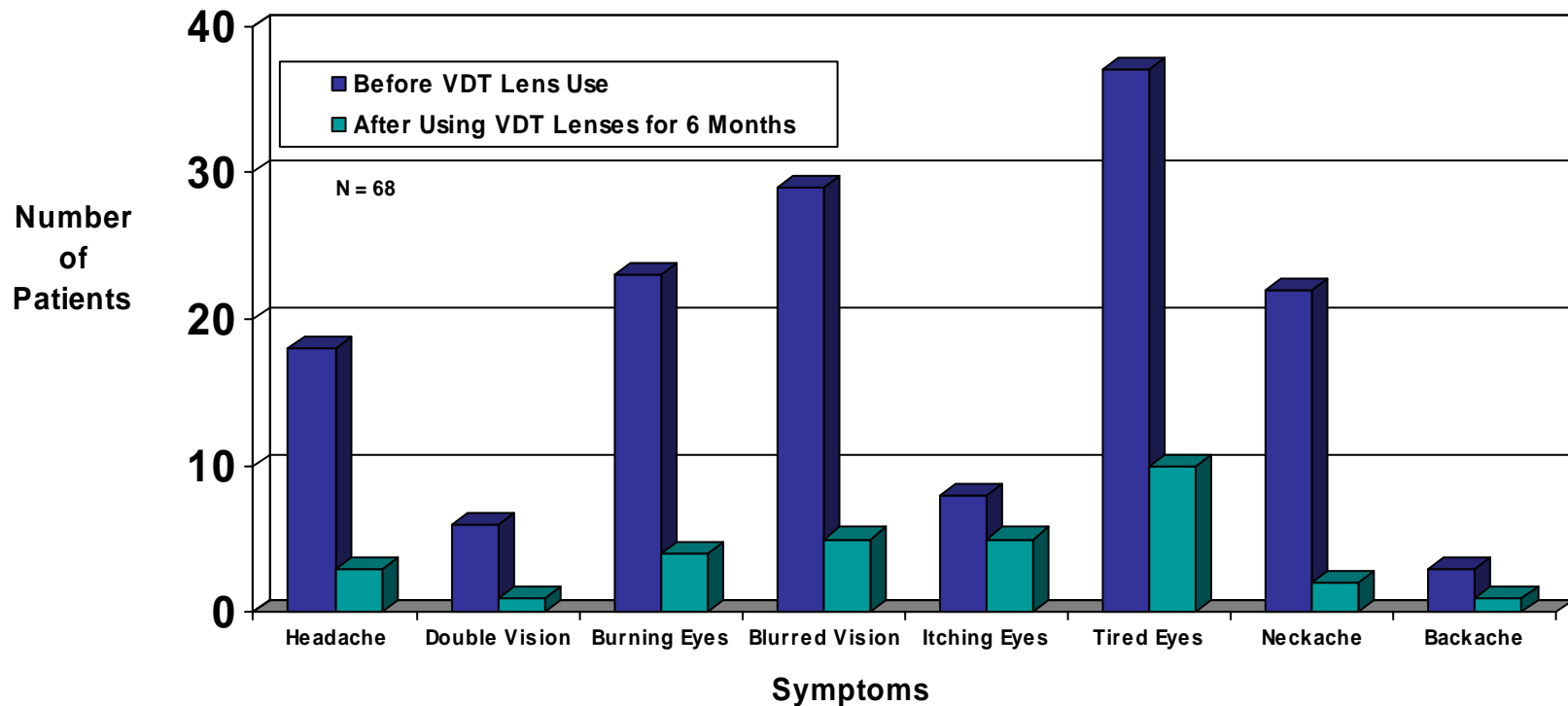
- Dry Eyes
 - Computer Use and Age
 - Treatments:
 - Cause dependent
 - Computer use
 - Use preservative free lubricating drops as needed
 - For exposure of ocular surface, take breaks
 - For decreased blink rate, practice 20/20/20 rule

Ocular Disorders and Treatments

- Dry Eyes
 - Computer Use and Age
 - Treatments:
 - Cause dependent
 - Age
 - Use preservative free lubricating drops as needed
 - Exposure of ocular surface, may require surgical intervention
 - Dysfunction of tear components
 - » For oil layer, flax seed oil or omega-3 fish oil dietary supplements
 - » For aqueous layer, lubricating drops, punctal plugs
 - » For mucosal layer, anti-inflammatory drops

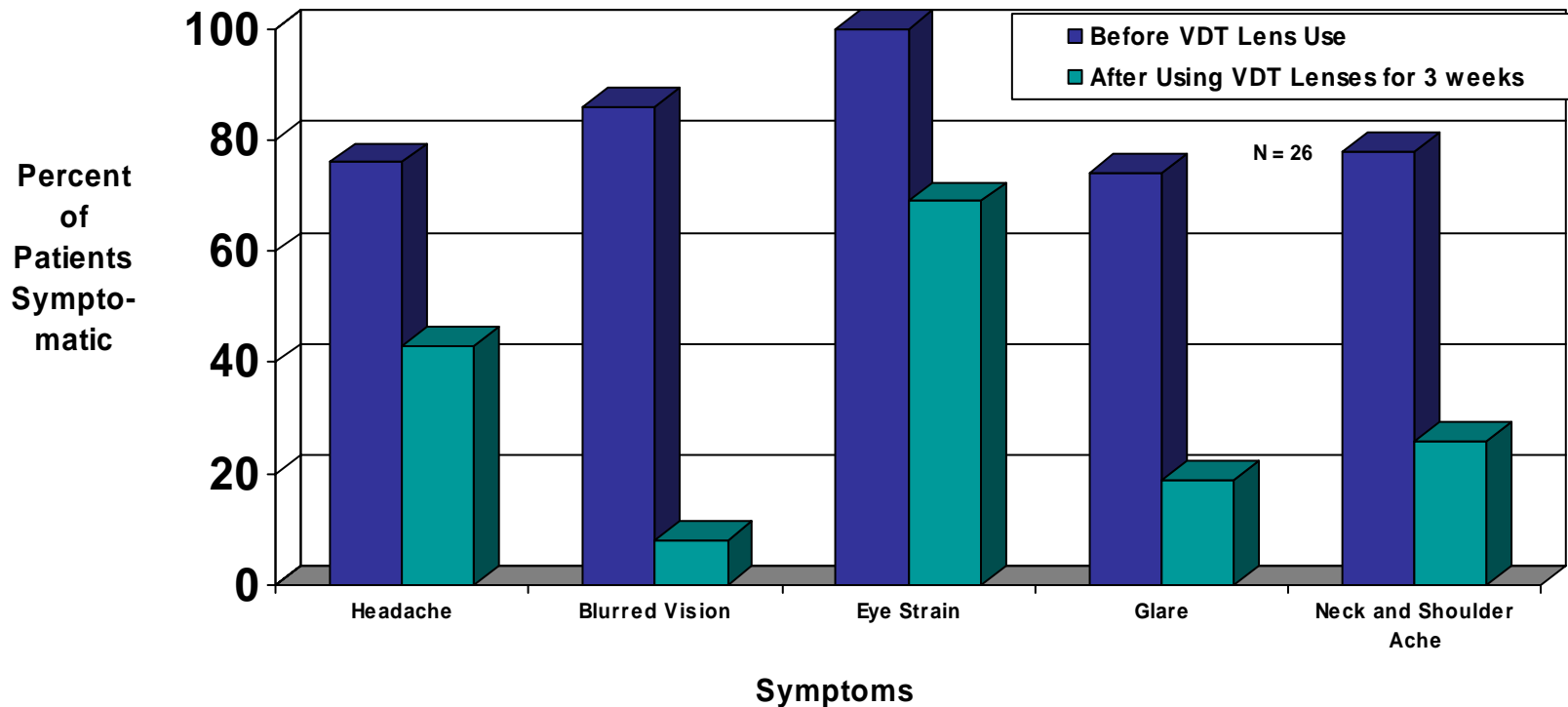
Research on the Efficacy of Computer Glasses

- Shurts and Bommarito 1996
- Lawrence Livermore National Laboratory



Research on the Efficacy of Computer Glasses

- Butzon, Sheedy and Nilsen 2002
- Ohio State University, College of Optometry



The Benefits of Addressing the Symptoms of CVS

- Decreased visual symptoms
- Decreased ocular ache
- Decreased physical pain
- Better morale
- Quality of life enhanced
- Increased productivity
- Reduction of lost work days
- Less workers compensation and disability claims

Increasing Productivity with Computer Glasses

- By reducing ocular and musculoskeletal symptoms by using computer glasses, assume 5 minutes per day is “saved” for more productivity.
- Cost of the 5 minutes previously lost each day (worker paid \$40/hr, 8 hrs/day, 220 work days/yr) is \$737/yr.
- $\$737 - \$250 \text{ cost of glasses} = \487 savings for the first year.
- \$487 to \$737 savings the next year because often only need new computer glasses in alternate years.

Contact Information

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Questions?

Thank You!